LEONARDO DA VINCI.

(Born 1452. Died 1519.)

THE fourth centenary of Leonardo da Vinci has been celebrated in Italy; in England the date of the death of this strange and legendary figure of the latter half of the fifteenth century, who was "still climbing after knowledge infinite," has passed almost unnoticed. Always one of the world's greatest names—for no artist of the past lent himself so readily to apotheosis—his fame has grown with the revelation of his greatness as a man of science. Other sons of the Renaissance, such as Leon Battista Alberti, were gifted with comprehensive genius, but the quality of Leonardo's endowment dwarfs their record when we sum up his activities as painter, sculptor, architect, engineer, hydraulician, anatomist, mathematician, geologist, botanist, astronomer, and geographer.

Apart from his guesses and achievements in these provinces, there is something in his personal character "super-European and silent," as Nietzsche terms it, "the characteristic of one who has seen too wide a circle of things good and evil." He behaved in such a way as to arouse the wonder of his contemporaries. "He dressed with originality and distinction, bore himself impressively. Surrounded, so to speak, by censer-swinging acolytes, he acted the part of hierophant and modern Empedocles, and was not far from being a precursor of Paracelsus."[1] He was

[1] B. Berenson, *The Study and Criticism of Italian Art*, London, 1916, p. 19.

unconditioned, above the law, the divine artist, the worker of miracles. Yet he was a solitary in the midst of court life, in the changes and chances of his employment, and speaks of the necessity of the solitary life in no uncertain voice:

"If you are alone, you belong entirely to yourself; if you are accompanied even by one companion, you belong only half to yourself, or even less in proportion to the thoughtlessness of his conduct; and if you have more than one companion, you will fall more deeply into the same plight."[2]

We see how the strange and solitary power is impressed on his red chalk drawing in his old age of his

> "silent face,
> The index of a mind forever
> Voyaging through strange seas of thought alone."

For all his cryptic utterances and the reserve of his spirit, we must not suppose that he was in any respect a charlatan, a suspicion that clings to the name of Paracelsus. His notebooks bear witness to the intense and laborious concentration of his mind upon the problems of science, physics, or engineering he had set before himself, to his patient and manifold industry, the ordered continuity and range of his effort. His personal character, as shown in the glass of his notebooks rather than in the distorting mirror of Vasari's famous *Life,* reveals an authentic greatness.

"I wish," he says, "to work miracles; I may have fewer possessions than other men who are more tranquil and those who wish to grow rich in a day."

"As a well-spent day brings happy sleep, so life well used brings happy death."

"Our body is subject to heaven, and heaven is subject to the spirit."

[2] E. McCurdy, *Leonardo da Vinci's Notebooks,* London, 1907, p. 166.

"Where there is most power of feeling, there of martyrs is the greatest martyr."

"Intellectual passion drives out sensuality."

"To the ambitious, whom neither the boon of life nor the beauty of the world suffices to content, it comes as a penance that life with them is squandered, and that they possess neither the benefits nor the beauty of the world."

These sublimations of Leonardo's experience are expressed with a concision which renders him, like Blake, the master of significant language.

Leonardo's life is a paradox. He recommends for the artist a life spent in the seclusion of the studio; his own was spent in courts; a wanderer, from place to place—Florence, Milan, Rome, finally Amboise in France. The most laborious of men, he has left little realized and achieved work in building and the arts behind him. None of his monumental projects of construction or town-planning seem to have been carried out, most of his paintings and sculptures were never executed, others were left half finished.

He has survived his masterpieces. Modern research has shown him to have been, not the capricious and inconstant artist whose performance was always less than his promise, but the most learned of painters, studying with the intentness of a scientist the medium in which he worked, the structure of the human body, plants, trees, and rocks, in order that he should know their essence and inner reality.

His habit of scientific investigation[3] in the end drew him aside from the practice of his art; he was rapt away by the Virgilian passion *rerum cognoscere causas.* It was impossible, Isabella d'Este found, to get a picture out of him. She had applied to a friar of the Carmelite Order

[3] According to Sabba da Castiglione, "when he ought to have worked at painting, in which he would without doubt have proved a new Apelles, he gave himself up entirely to geometry, architecture, and anatomy." *Ricordi,* Venice, 1565, 115, v.

whom she knew, to know what manner of life the master was leading, and the answer was returned that he was "entirely wrapped up in geometry, and has no patience for painting." The whole world of knowledge was his province. In reading his notebooks there is at first a feeling of disappointment at the meagerness of the scientific result, but this is counterbalanced by the realization that he is the first of the moderns in his belief in experimental methods, his distrust for mere authority in science as in the arts he practised. "Whoever in discussion," he writes, "adduces authority, uses not intellect, but rather memory."[4] He has been loosely said to have been the forerunner of Bacon, Watt, Newton and Harvey, but it cannot be maintained that he anticipated their discoveries in any definite sense. Though he set down in unusually large letters "the sun does not move,"[5] and surmised that the earth was a star "much like the moon," and knew that blood moved,[6] and so forth, his actual achievements were in the invention of certain ingenious devices, such as the diving-bell and the lifebelt, and in the employment of a definitely scientific method, as in his discovery of the significance of fossils found in the mountain ridges of Lombardy as showing the waters at one time covered the earth.

"If you should say that the shells which are visible at the present time within the borders of Italy, far away from the sea at great heights, are due to the Flood having deposited them there, I reply that, granting this Flood to have risen seven cubits above the highest mountain....those shells which always inhabit near the shores of the sea

[4] "Those who study only the authorities and not the works of nature are in art the grandsons and not the sons of nature, which is the supreme guide of good authorities." *Codice Atlantico,* 141, v. b.

[5] J. P. Richter, *Scritti letterari di Leonardo da Vinci,* London, 1883, Vol. II, p. 152.

[6] "The heart is a muscle of great strength, much stronger than the other muscles....The blood which returns when the heart opens again is not the same as that which closes the valves." Richter, *op. cit.,* Vol. II, p. 132.

ought to be found lying on the mountain side, and not at so short a distance above their bases, and all at the same level, layer upon layer. Should you say that the nature of these shells is to keep near the edge of the sea, and that as the sea rose in height the shells left their former place and followed the rising waters to their highest level: —to this I reply that the cockle is incapable of more rapid movement than a snail out of water, or is even somewhat slower, since it does not swim, but makes a furrow in the sand, and supporting itself by means of the sides of this furrow it will travel between three and four braccia a day; and therefore with such a motion as this it could not have traveled from the Adriatic Sea as far as Monferrato in Lombardy, a distance of two hundred and fifty miles, in forty days....

"If you should say that the shells were empty and dead when carried by the waves, I reply that where the dead ones went the living were not far distant, and on these mountains are found all living ones, for they are known by the shells being in pairs, and by their being in a row without any dead....where the valleys have never been covered by the salt waters of the sea, there the shells are never found. ....Such things are far more ancient than letters, it is not to be wondered at if in our days there exists no record of how the aforesaid seas extended over so many countries. ....But sufficient for us is the testimony of things produced in the salt waters, and now found again in the high mountains far from the seas."[7]

His science was, in the main, applied science, as might be expected from the realistic cast of his mind. He seems to have seen every problem as, in a sense, a problem of engineering. As Mr. Havelock Ellis writes: "All nature was a dynamic process of forces beautifully effecting work,

[7] Quoted and translated in Mr. E. McCurdy's invaluable *Leonardo da Vinci's Notebooks*, London, 1907, pp. 106-109.

and it is this as it were instinctive vision of the world as a whole which seems to give Leonardo that marvelous flair for detecting vital mechanism in every field."

His studies in various provinces of natural science can hardly be touched on; some of the notes on geological, physical, botanical, and physiological subjects have been collected and interpreted in a historical light by G. B. de Toni, Edmondo Solmi, O. Werner,[8] and others, but a great part still await full scientific and historical analysis.

His manuscripts contain allusions to his mathematical studies, and in the "Philosophical Maxims" he maintains "there is no certainty in sciences where one of the mathematical sciences cannot be applied, or which are not in relation with mathematics."[9]

In astronomy, he, like his contemporaries, accepted the Ptolemaic theory of the earth as fixed, with the sun and moon revolving round it, and so represents it in a diagram. But he has also recorded, in letters which mark its importance in his mind, his intuition that the sun does not move. He points out the universality of gravitation, not only in the earth, but even in the moon,[10] and asserts that the earth is not the center of the solar system "nor yet in the central point of the universe, but in the midst of its elements by which it is accompanied, and to a person standing on the moon our earth would appear with the elements of water, and so fulfil the same function as the moon does for us."

He studied the action of heat, optics, acoustics, magnetism. He anticipated Pascal in noting that any liquid in communicating vessels, however different in form, remained on the same level. He touched on the resistance,

[8] G. B. de Toni, *Frammenti Vinciani,* Parti I-VI; E. Solmi, *Nuovi Studi sulla filosofia naturale di Leonardo da Vinci*; O. Werner, *Zur Physik Leonardo da Vincis,* Berlin, 1913.

[9] Quoted in J. P. Richter, *Scritti letterari di Leonardo da Vinci,* London, 1883, Vol. II, p. 289.

[10] Richter, *op. cit.,* Vol. II, p. 136.

condensation, and weight of air, on reflex action, embryology, and botany.

Leonardo da Vinci's anatomical researches were without influence and remained for long unnoticed. The anatomical sketches give some hint of what the projected treatise of Della Torre might have been, but as the project was never realized, the medical schools had to wait for yet another generation before the subject was placed on a sound basis by Vesalius.

He was "the best anatomist at that time in the world," in the words of the great surgeon of Georgian days, William Hunter, who saw his anatomical drawings in the King's Library, and was astonished to see Leonardo revealed in those then unknown studies as a "general and deep student, the first man we know of who introduced the practice of making anatomical drawings."[11] Marc Antonio della Torre, who held the chair of anatomy at the University of Padua, was his friend, and Vasari records that the anatomist was "wonderfully assisted by the mind, work, hand, of Leonardo, who made a book, drawn in red chalk, and annotated with the pen, of the subjects he dissected with his own hand." Many of the anatomical studies are still unsurpassed, combining scientific clearness with artistic beauty. Professor Holl[12] points out as examples of Leonardo's exact observation, his representation of the curvature of the pelvis, and its position in the body, and the resultant curvature of the spine, and of the thorax with the proper inclination of the ribs and division of the breast-bone, observations only known to the world of science after Nägele's researches. Leonardo's researches were made at a time when the Church taught the sacred-

[11] *Two Introductory Letters,* London, 1784, pp. 37-39.

[12] M. Holl, *Die Anatomie des Leonardo da Vinci.*

ness of the human corpse, and was ready to punish as sacrilege the use of the scalpel.[13]

What was his attitude to the Church which would have stayed his hand? He may have been clearly disdainful of the established religion, as he was clearly disdainful of the frailties and practices of the priesthood; or again he may have regarded the faith of his age "with imaginative acquiescence, if no more."[14] In his will, made when his end was near, he provided for masses to be said and candles to be offered in three different churches of Amboise; while Vasari, in the first edition of the *Lives* (which he afterward suppressed), says that Leonardo "was of so heretical a cast of mind, that he conformed to no religion whatever, accounting it, perchance, much better to be a philosopher than a Christian." His notebooks, private and informal records as they are, are silent, but it may be surmised that his choice of reason rather than authority would have led him away from the levels of revealed religion. In the subjects that he pursued he had no need of that hypothesis. He sings hymns to Law and Causation:

"Nature never breaks her own law.

"O marvelous necessity, thou with supreme reason constrainest all efforts to be the direct result of their causes, and by a supreme and irrevocable law every natural action obeys thee by the shortest possible process.

"Who would believe that so small a space could contain the images of all the universe? O mighty process, what talent can avail to penetrate a nature such as thine? What tongue will it be that can unfold so great a wonder? Verily none. This it is that guides the human discourse to the considering of divine things."[15]

Leonardo, who sums up war as a "bestial frenzy" (in

[13] McCurdy, *op. cit.*, p. 6.

[14] *Encyclopædia Britannica*, art. "Leonardo."

[15] *Leonardo da Vinci's Notebooks*, p. 117.

the descriptive passage entitled "The Way to Represent a Battle"), was the inventor of numerous engines of war, steam guns and breech-loading arms with screw breech-block, and in the draft of a letter in which he offers his services as architect and military engineer to Ludovico Sforza, Duke of Milan, he claims that he can "construct bridges that are very light and strong and very portable, with which to pursue and defeat the enemy, and others more solid, which resist fire or assault," also "a kind of cannon which is light and easy of transport, with which to hurl small stones like hail," "catapults, mangonels, *trabocchi,* and other instruments of admirable efficacy not in general use," and "armored wagons carrying artillery which shall break through the most serried ranks of the enemy, and so open a safe passage for the infantry";[16] he can also construct "subterranean passages either straight or winding, passing if necessary underneath trenches or a river."[17]

As far as the evidence of Leonardo's manuscripts can substantiate the claims put forward, they have been found to have been correct; and Dr. Müller-Walde,[18] in that portion of his work dealing with Leonardo as a military engineer, has shown that Leonardo did in fact study the construction and use of the engines of warfare mentioned in the first seven clauses of the letter.

In the arts of peace, his schemes and sketches for canalization and the lay-out of towns are no less remarkable. According to specialists' opinions, Benedetto Castelli, who is considered to be the actual originator of the Lombardy canal system, appears to have studied Leonardo's schemes, in which practical standards for hydraulic engineering are

[16] Tanks?

[17] *Codice Atlantico,* 1 391, v.

[18] *Leonardo da Vinci: Lebensskizze und Forschungen,* Munich, 1889-90, pp. 139-232.

already worked out.[19] He wished to lay out cleaner and healthier cities, so that the people would not need to live "packed together like goats, and pollute the air for one another," and proposed to Il Moro to build ten cities, each with 5000 houses and accomodating 30,000 inhabitants. These cities are to be seated on rivers regulated by locks; the streets are to be as wide as the height of the houses, and laid out with wide squares and market-places. Moreover, he provides two kinds of streets on different levels, the higher and spotless walks for foot passengers, and the lower for traffic, which can be cleaned by flushing from locked rivers.[20] In his notebooks are found a wealth of designs, exhausting every possible combination of circular and polygonal ground-plans for domed public buildings and churches. As he himself states, it was his intention to write a treatise on the theory of cupola construction. His devices and designs for hydraulic work, and for war-like machines, were, for the most part, within the limits of possible construction in his day. It is otherwise with the problem that occupied so much of his time, that of flight.

He had for many years watched the flight of birds, and made himself, thanks to an amazingly keen power of fixing rapid movement, familiar with every characteristic of wing action. The subject gives its name to a treatise which exists in a more or less complete form—*Il Codice sul volo degli uccelli*, and is also treated in the *Codice Atlantico* and other of Leonardo's manuscripts. The conviction grew on him that men might raise themselves above the earth on wings, for:

"A bird is an instrument working according to mathematical law, which instrument it is within the capacity of man to reproduce, with all its movements, but not with a

[19] M. Baratta, *Leonardo da Vinci, ed i problemi della Terra*, Turin, 1903.

[20] O. Sirén, *Leonardo da Vinci*, Yale University Press, 1916, p. 123.

corresponding degree of strength, though it is deficient only in the power of maintaining equilibrium. We may therefore say that such an instrument constructed by man is lacking in nothing except the life of the bird, and this life must needs be supplied from that of man."[21]

Flight is a natural phenomenon, and consequently its laws are to be deduced by observation of nature. Yet Leonardo doubted the adequacy of strength of the human agent to accomplish more than short flights, and sought to supplement it by a screw-propeller. He has a drawing of a large screw constructed to revolve round a vertical axis. "The notes at the side and below the drawing tell of the materials and dimensions, and reveal also the purpose which it was intended to serve. M. Govi, who first called attention to the significance of these passages, speaks of them as proving not only that Leonardo invented the screw-propeller, but that he had considered small paper models for this purpose, which were set in motion by fine bent steel wires."[22]

He must have, at one moment, at any rate, felt sure of success, when he wrote triumphantly that "the huge bird will take his first flight high aloft on the ridge of his great Ceceri—the mountain between Majano and Fiesole—he will fill the universe with wonder and all writings with his fame." The experimental flight must have failed, but from his own day Leonardo has not been judged by his achievement, for, in the words of his earliest biographer, "his spirit was never at rest, his mind was ever devising new things."

M. JOURDAIN.

OXFORD, ENGLAND.

[21] *Codice Atlantico*, 161, R. a.

[22] *Nineteenth Century*, July, 1910.